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Research on Railway Freight Market Share Based on the Whole Process of Transport

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Abstract

This paper develops a mathematical model to quantify the market share of given freight transport corridor. By analysing the whole process of door to door freight transport, the generalized cost model of railway and highway is established, respectively. A case study of long-distance transport in China's inland cities is subsequently conducted to explore market share of railway and highway. At last, the sensitivity of influence factors is analysed. We find that the average train speed, waiting time to be loaded, container volume and transport distance can significant affect the railway market share. The railway market share increases as the average train speed, container volume and transport distance increase, while decreases as the time waiting to be loaded increases. When the average trains speed is over 50 km/h, or the time waiting to be loaded is less than 1.5 d, railway market share is over 50%. Moreover, railway is more competitive in high capacity and long-distance freight transport. We also find that the result of single factor's change is limit, while the change of multi-factors can affect the railway market share greatly.

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Keywords: freight transportation; generalized cost; Logit model; market share; transport process

1. Introduction

Railway transport has many advantages which highway, waterway and air transport are incomparable, such as safety, high-speed, long distance, large capacity, little pollution, little effect by weather and so on. While the market

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share of railway freight transport has declined from 14.6% in 2004 to 8.9% in 2013, decreasing by 0.57% per year on average (NBSC, 2014). Therefore, it is necessary to study the railway competitiveness among multiple transportation modes in transportation corridor and analyse the factors influencing the railway market share. The results may provide theoretical basis to improve the railway transport services and raise the railway market share.

There has been much literature on the competitiveness of railway transport, which concentrated more on rail passenger transport (Xu and He, 2008; Ye and Wang, 2010; Cao and Cao, 2011). There were few researches on the railway freight market share, Chen (2012) used Logit model to calculate the market share between highway and railway, Ye (2013) studied the market share of the Guangzhou-Shenzhen railway freight transport based on Inflow-Logit model. The researches on freight had more concentration on the multiple factors when choosing the transport mode. Cost, time, reliability, security, punctuality, speed, convenience and other factors were analysed when choosing the railway in freight transport (Pierre and Dominique, 2004; Romeo and Edoardo, 2005; Nikolaus and Zachary, 2008; Chen, 2012). Allan (2006, 2007) investigated the railway market share from policy, carrying out multimodal transport and expanding break bulk cargo transport. However, some factors above are cross and overlapping, and a large amount of data is needed for calibration, which have poor reliability when analysing the railway transport market share. However, the reliability could be improved while calculating the railway transport market share from the time and cost of the whole transport process in freight transport.

In this paper, a generalized cost function of railway and highway is established based on the analysis of the whole process in door-to-door freight transport. The share rates of the two modes are calculated according to improved Logit model. Furthermore, taking the long-distance freight transport among China's inland cities for example, the railway freight market share and its influence factors are analysed. At last, the development strategy for raising the railway freight shares is proposed.

The rest of this paper is organized as follows. Section 2 analysed the transport process of rail and road freight transport. In Section 3, the generalized cost function and market share calculation model are presented. A case study and sensitivity of the influence factors are investigated in section 4. Finally, the conclusions are given in the last section.

2. Analysis of rail and road transport process

In long-distance inland transport, road and rail are the main modes, so this article considers only road and rail in freight transport. The main process of road transport and rail transport is shown in Figure 1.

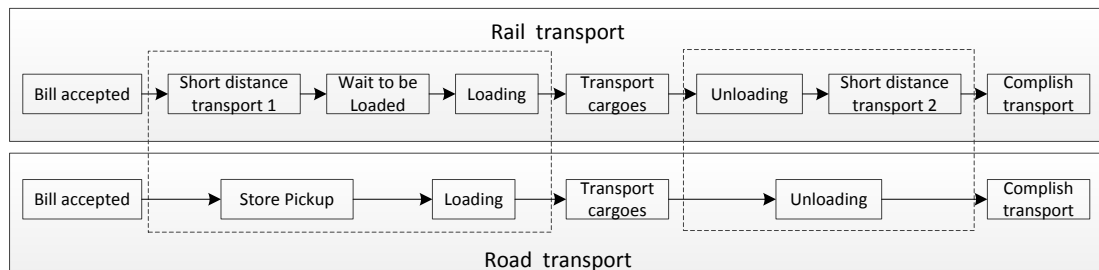


Fig.1. Rail and road freight transport processes

In railway freight transport, road transport is often required in the beginning and the ending of the whole process to achieve door-to-door. After the transport applications are submitted, cargoes will be transited to freight station by trucks (short distance transport 1), then they will be loaded in the freight station (including procedures handled and accumulation of freight trains). After loading, the cargoes will be transported by railway, during which vehicles may be regrouped. At last, the cargoes will be unloaded in terminal station, and then they are transported to destination by trucks (short distance transport 2). In this paper, we simplify the process of handling procedures and accumulation of freight trains into the step of “wait to be loaded”, the process of trains regroup is simplified into “transport cargoes”.

In road freight transport, the loading and discharging of cargoes only need once while transporting. When the

transport applications are submitted, the cargoes will be loaded. Then they will be transported by trucks to the destination. The whole process will complete after unloading the cargo at destination.

3. Calculation model

3.1. Rail transport generalized cost function

Assume that all steps of rail transport are independent, and the customers will choose the best mode of transport for themselves. We converted the actual costs and time of every step into the generalized cost. The generalized cost function of rail transport can be described as follows:

$$C_R = \alpha \cdot T_R + F_R = \alpha \cdot \sum_p t_R^p + \sum_p F_R^p \quad (1)$$

$$T_R = t_R^{s_1} + t_R^{s_2} + t_R^w + t_R^l + t_R^t + t_R^u = \frac{S_{s_1}}{v_c} + \frac{S_{s_2}}{v_c} + \frac{S_t}{v_t} + t_l + t_u + (t_{w_1} + t_{w_2}) + t_o \quad (2)$$

$$F_R = F_R^{s_1} + F_R^{s_2} + F_R^l + F_R^t + F_R^u = n(f_R^{s_1} + f_R^{s_2} + f_R^l + f_R^t + f_R^u) \quad (3)$$

Where, C_R is the generalized cost of rail transport; α is the time value of the customer; t_R^p is the time on step p of rail transport; F_R^p is the cost on step p of rail transport; s_1 , s_2 , w , l , t , and u are the process of short distance transport 1, short distance transport 2, waiting to be loaded, loading, transit by rail, unloading, respectively; v_p is the average speed of step p ; t_o is the other lost time; S_p is the distance of step p ; f_R^p is the cost of unit weight of cargo in step p by railway.

3.2. Road transport generalized cost function

For road transport, the time waiting for picking up is short. Loading and unloading time are short enough to be ignored in the total delivery time. So we choose the transit time as the total road transport time. Road transport generalized cost function is as follow:

$$C_H = \alpha \cdot T_H + F_H \quad (4)$$

Where, C_H is the generalized cost of road transport; F_H and T_H are the total cost and the total time of road transport, respectively.

3.3. Market share calculation model

Logit model is used extensively for calculating the market share of various transport modes. Therefore, this paper introduces Logit model to calculate the market share of different modes in one freight transportation channel. As for discrete choice models, the utility function U_i consists of the utility function V_i based on observable factors and utility function ε_i based on unobservable ones (Ye and Wang, 2010):

$$U_i = V_i + \varepsilon_i \quad (5)$$

When ε_i follows independent Gumbel distribution, the probability of customers choose transit mode i is:

$$P_i = \frac{\exp(V_i)}{\sum_i \exp(V_i)} \quad (6)$$

In general Logit model, when the value of utility function of a certain mode increases, the results grow exponentially. To eliminate this drawback, we introduce the average generalized cost. We assume that cargoes are carried by batch, and the customers' choices of transport modes are independent of each other. The market share of freight transit mode is:

$$P_i = \frac{\exp(V_i / \bar{V})}{\sum_i \exp(V_i / \bar{V})} = \frac{\exp(-C_i / \bar{C})}{\sum_i \exp(-C_i / \bar{C})} \quad (7)$$

Where, P_i is the probability of the customers selecting transit mode i ; C_i is the generalized cost of transit mode i ; \bar{V} and \bar{C} are the average utility function and the average generalized cost within the transport corridor of all transport modes, respectively.

4. Case Study

4.1. Values of parameters

In this paper, we choose the railway competitiveness of the Liuzhou-Shanghai freight transport corridor as case study. Assuming that a 20-foot container needs to be transported from industry A in Liuzhou to industry B in Shanghai. Industry A is 20 km far from the Liuzhou Station, and industry B is 40 km far from Shanghai South Railway Station.

Based on formula calculated by Wang et al. (2009, 2011), we can calculate the rail transit time, road transit time and road transit cost. The rail transit cost, loading and unloading cost, and distance are calculated by 12306 computing system. The value of t_R^w refers to the statistical data from Railway Ministry in 2011 (there are 500000 vehicles request loading in one day, while average daily loading is 168000). The time of loading or unloading is 3h. v_i is 33.2km/h, α is 40 RMB/h, and f_R^p is 400RMB/TEU. The distance, time, cost of one 20-foot container transport from Liuzhou to Shanghai is shown in Table 1.

Table 1. Parameters of transport from Liuzhou to Shanghai

Transit mood	Parameters	Process of transit						Total
		s_1	w	l	u	t	s_2	
Rail	Distance /km	20	-	-	-	1837	40	1897
	Time /day	0.04	2.5	0.13	0.13	2.3	0.06	5.16
	Cost /RMB	400	-	195	195	5449.4	400	6639.4
	Generalized cost /RMB	438.4	2400	319.8	319.8	7657.4	457.6	11593
Road	Distance /km	-	-	-	-	1697	-	1680
	Time /day	-	-	-	-	2.52	-	2.52
	Cost /RMB	-	-	-	-	8457.95	-	8457.95
	Generalized cost /RMB	-	-	-	-	10877.15	-	10877.15

4.2. Sensitivity Analysis

In order to study how parameters affecting rail freight market share, we adjusted some parameters including train speed, time waiting to be loaded, cargo transport distance, and cargo volume. Each factor's influences on the market share are shown in Figure 2.

Figure 2(a) depicts that when the average train speed changes from 33.2 km/h to 100 km/h, the rail freight market share correspondingly increases. When the average speed exceeds 50 km/h, rail freight market share will exceed the rate of road. As shown in Figure 2(b), when the waiting time to be loaded was taken to be 2.5d, 2d, 1.5d, 1d, 0.5d, or 0d, the market share of rail increase rapidly. When the waiting time decreases to 1.5 d, rail freight market share will be 50.57%. Figure 2(c) shows how market share changes when the quantity of containers changes from 1TEU to 10 TEU in long-distance. With the increase of container volume, the advantages of rail transport become apparent. When the volume is beyond 5 TEU, the increase of rail market share tends to be slow. As shown in Figure 2(d), we change the destination city into Hangzhou, Nanchang, Changsha, and Guilin. The distance of rail transport between Liuzhou and the four cities respectively to be 1644 km, 1058 km, 733 km, and 190 km. Assume that other parameters are not change. With shorter transport distances, road transport is more inclined to be chosen. In short-haul cargo transport, road transport sharing rate is much higher than the market share of rail.

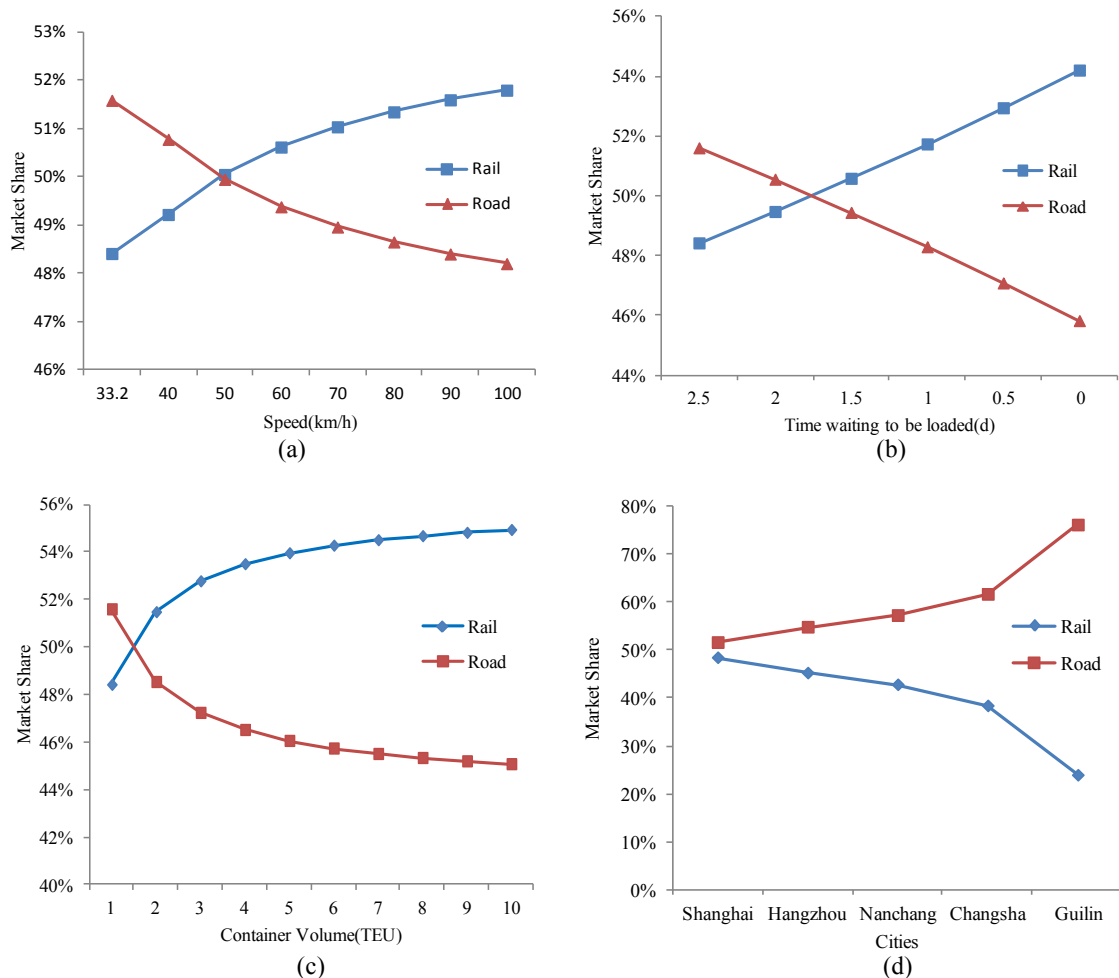


Fig.2. Influences of the four factors on the market share

4.3. Scenario Analysis

Based on the above analysis, we take some crucial points as variables to analyze how multiple factors influence the market share of rail. Four scenarios are set as follows:

Scenario 1: take the basic values in table 1 and fig 2(d) to calculate rail market share from Liuzhou to the five cities.

Scenario 2: change the average speed of trains to 50 km/h, and other factors remain unchanged.

Scenario 3: change the average speed of trains to 50 km/h, cargo's waiting time to 1.5 d, and other factors remain unchanged.

Scenario 4: change the average speed of trains to 50 km/h, cargo's waiting time to 1.5 d, container volume to 5TEU, and other factors remain unchanged.

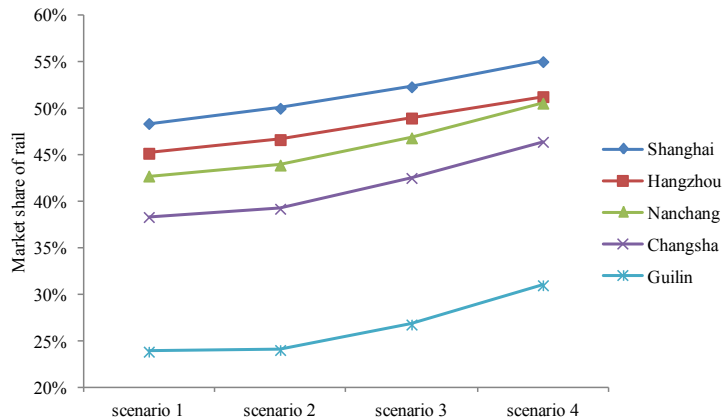


Fig.3. Changes in the market share of rail freight in the four scenarios

As shown in Figure 3, we calculated the market share of rail in the four scenarios, respectively. More factors are changed to analyze the market share of rail from scenario 1 to scenario 4. With more factors taken into account, the market share of rail increased to be higher. Under the same scenario, the shorter the travel distance is, the greater the market share of rail enhanced. Improving one indicator a lot to get higher rail freight market share may be unsubstantial, but we can improve some indicators together with little change to get the same results.

5. Conclusion

In this paper, we defined a performance indicator- rail market share- to reflect the attraction of rail in one corridor against with road. The whole process of rail transport and road transport is analyzed. Then, generalized cost function is established, respectively. An improved Logit model is used to calculate the railway market share.

Average train speed, waiting time to be loaded, container volume and transport distance are the main factors that can influence the railway market share. The railway market share increases as the average train speed, container volume or transport distance increases, while decreases as the time waiting to be loaded increases.

When the average trains speed is over 50 km/h, or the time waiting to be loaded is less than 1.5 d, railway market shares are over 50%. Moreover, railway is more competitive in high capacity and long-distance freight transport. The result of single factor' change is limit, while the change of multi-factors can affect the railway share rate greatly. With the same improvement of service, the market share of shorter travel distance may increase higher.

Rail transport is more suitable for long-distance and large volume cargo transport. In order to get higher market share, railway transport enterprise should make some changes to improve service efficiency, such as fixed stopping points, routings and service schedules. Less waiting time and marshalling will increase the attractiveness of rail.

Though the whole process of the transport is considered, some parts of the processes are simplified. In further study, we need to refinement the transport processes to improve the accuracy of the results.

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References

- Allan G. W. (2006). The non-bulk market for rail freight in Great Britain. *Journal of Transport Geography*, 14, 299-308.
- Allan G. W. (2007). Appropriate indicators of rail freight activity and market share: A review of UK practice and recommendations for change. *Transport Policy*, 14, 59-69.
- Cao D. Z., & Cao S. J. (2011). The inter-city high-speed railway competitiveness analysis on short range passenger market. *Technology & Economy in Areas of Communications*, 68, 75-77.
- Chen F. (2012). Research on the market share of freight transportation. *Railway Operation Technology*, 18, 24-27.
- National Bureau of Statistics of China (NBSC), 2014. Available: <http://data.stats.gov.cn/workspace/index?m=hgyd>.
- Nikolaus F., & Zachary P. (2008). Cartier or Mode- The dilemma of shippers' choice in freight modelling. *STRC*.
- Pierre A., Dominique P., & Isabelle T. (2004). Modelling a rail/road intermodal transportation system. *Transportation Research Part E*, 40, 255-270.
- Romeo D., Edoardo M., & Lucia R. (2005). Logistics managers' stated preferences for freight service attributes. *Transportation Research Part E*, 41, 201-215.
- Wang X., Meng Q., Miao L., & Fwa T. F. (2009). Impact of landbridge on port market area: model development and scenario analysis. *Transportation Research Record*, 78-87.
- Wang X. C., & Meng Q.. (2011). The impact of land bridge on the market shares of Asian ports. *Transportation Research Part E*, 47, 190-203.
- Xu W. T., He S. W., Song R., & Li J. (2008). Disaggregate Modal-split Model Considering Congestion Pricing. *Journal of Transportation Systems Engineering and Information Technology*, 6, 96-102.
- Ye J. (2013). Freight share rate of the Guangzhou-Shenzhen Railway based on Influo-Logit model. *Railway Freight Transport*, 31, 17-21.
- Ye Y. L., & Wang Y. S. (2010). Research on travel mode choice behavior in Shanghai-Hangzhou transport corridor. *Journal of the China Railway Society*, 32, 13-17.